HOW TO STEAL FROM NATURE

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Report Documentation Page

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Start from here . . .

- The abilities of ‘living machines’ can exceed those of man-made ones
- Nature’s solutions survive
- Physics rules, so we can copy and adapt

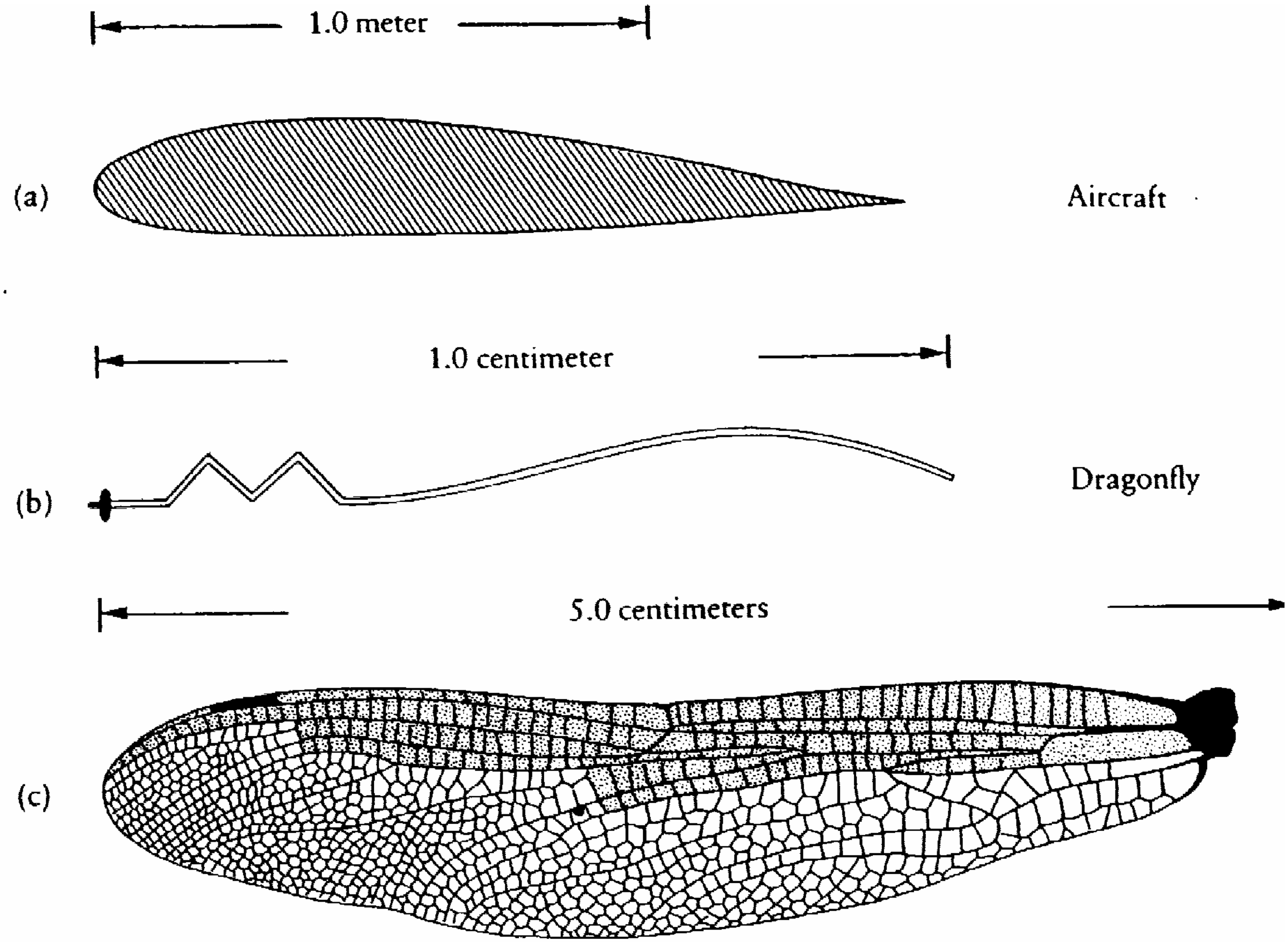
HOW CAN WE TRANSFER THE TECHNOLOGY?

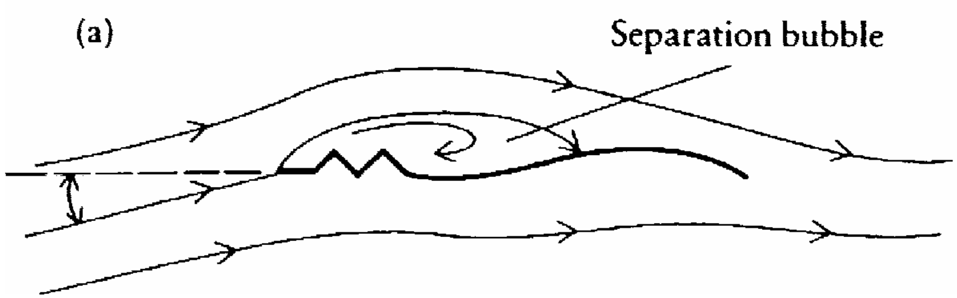
Solutions from biology ? ? ? ? ? ? ? ? ? ? ? ? ? ?

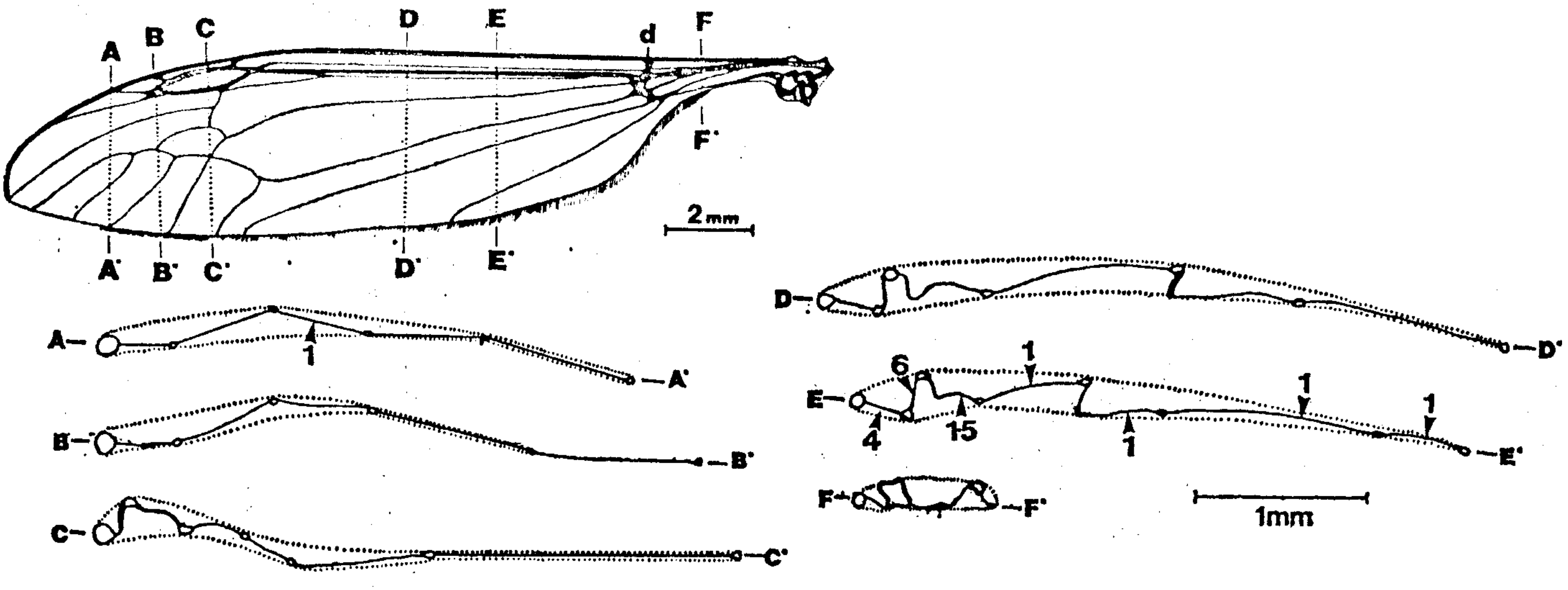
- Competition selects and optimises - but for what?
- Optimisations are local - organisms are multifunctional, have to work while they grow, and are derived from earlier designs
- Optimisation means ‘good enough’
- Nature may be solving different problems - minimum energy or maximum competitiveness?

Biology | Technology

Wet, flexible	Dry, rigid
Heterogeneous	Homogeneous
Anisotropic	Isotropic
Curved	Rectilinear
Non-metallic	Metallic
Factory <<< product	Factory >>> product
Multifunctional	Limited functionality
Self-repairing	Repair or replace

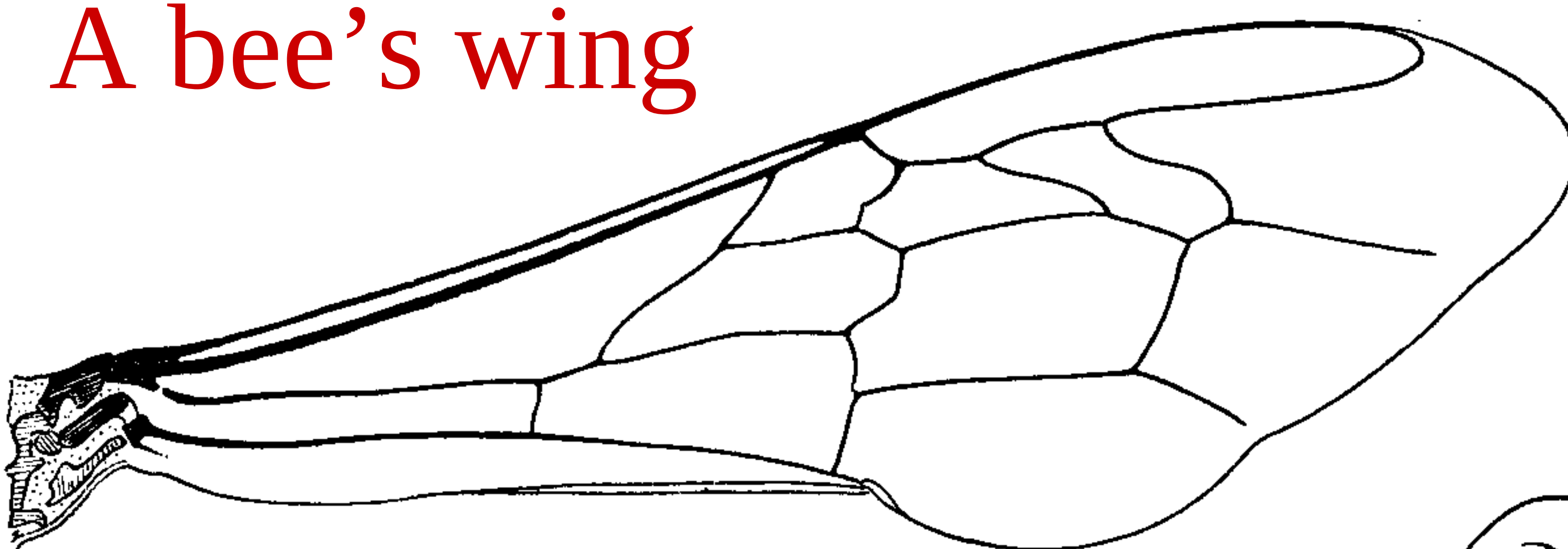

1.0 meter
(a)
Aircraft
1.0 centimeter
(b)
Dragonfly
5.0 centimeters
(c)

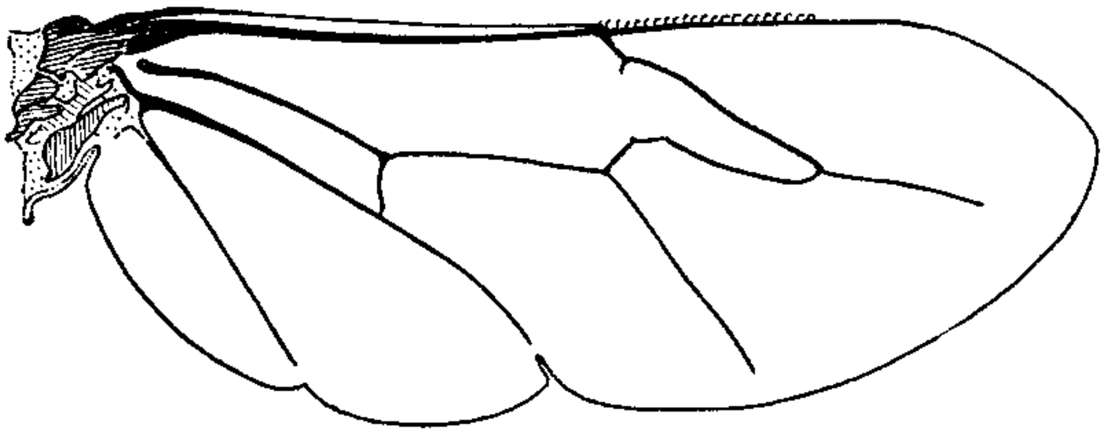

(a)
Separation bubble

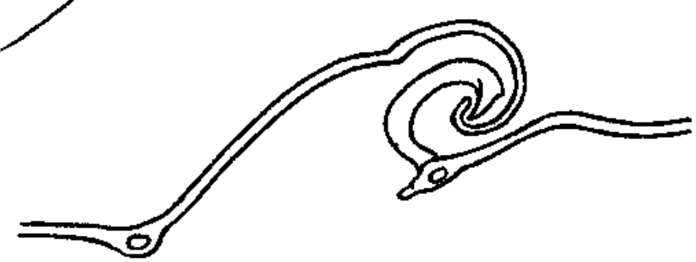


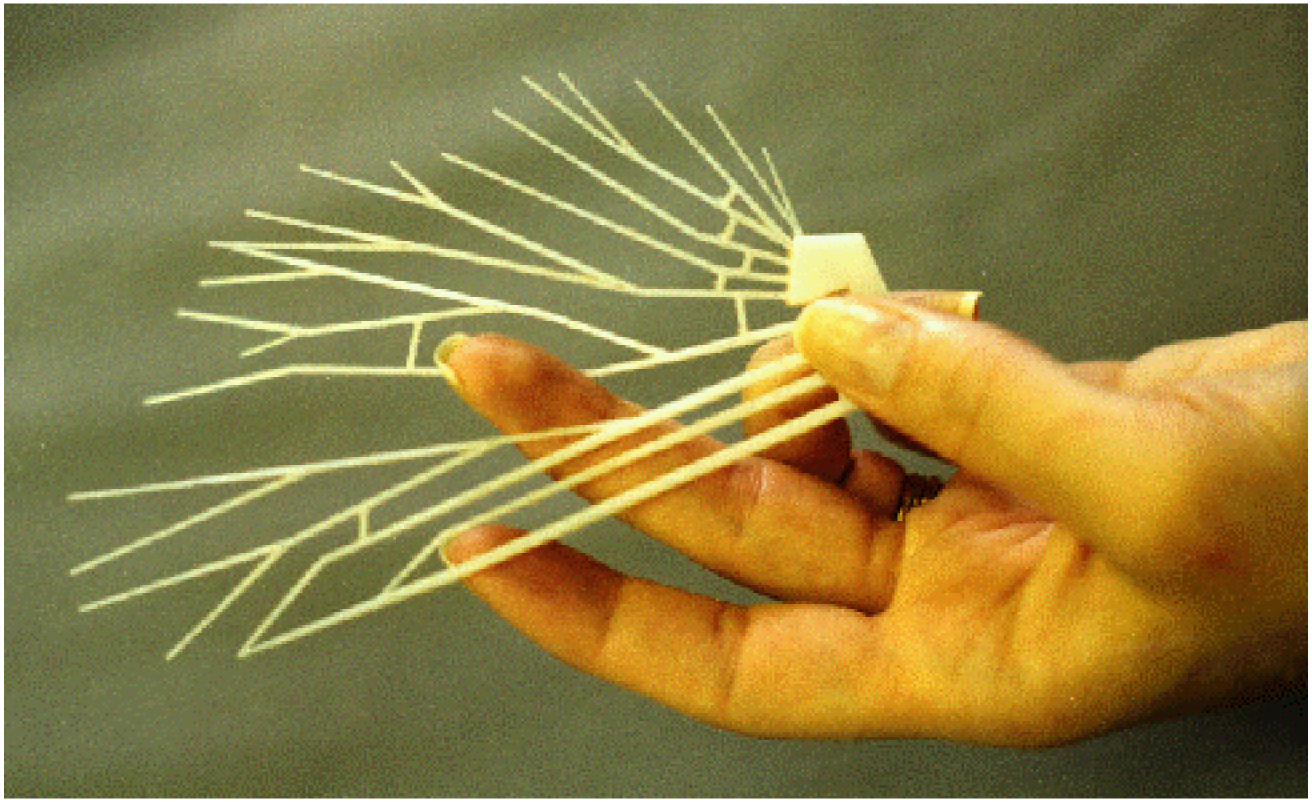
Sections through the wing of a tipulid (crane fly)

A bee’s wing



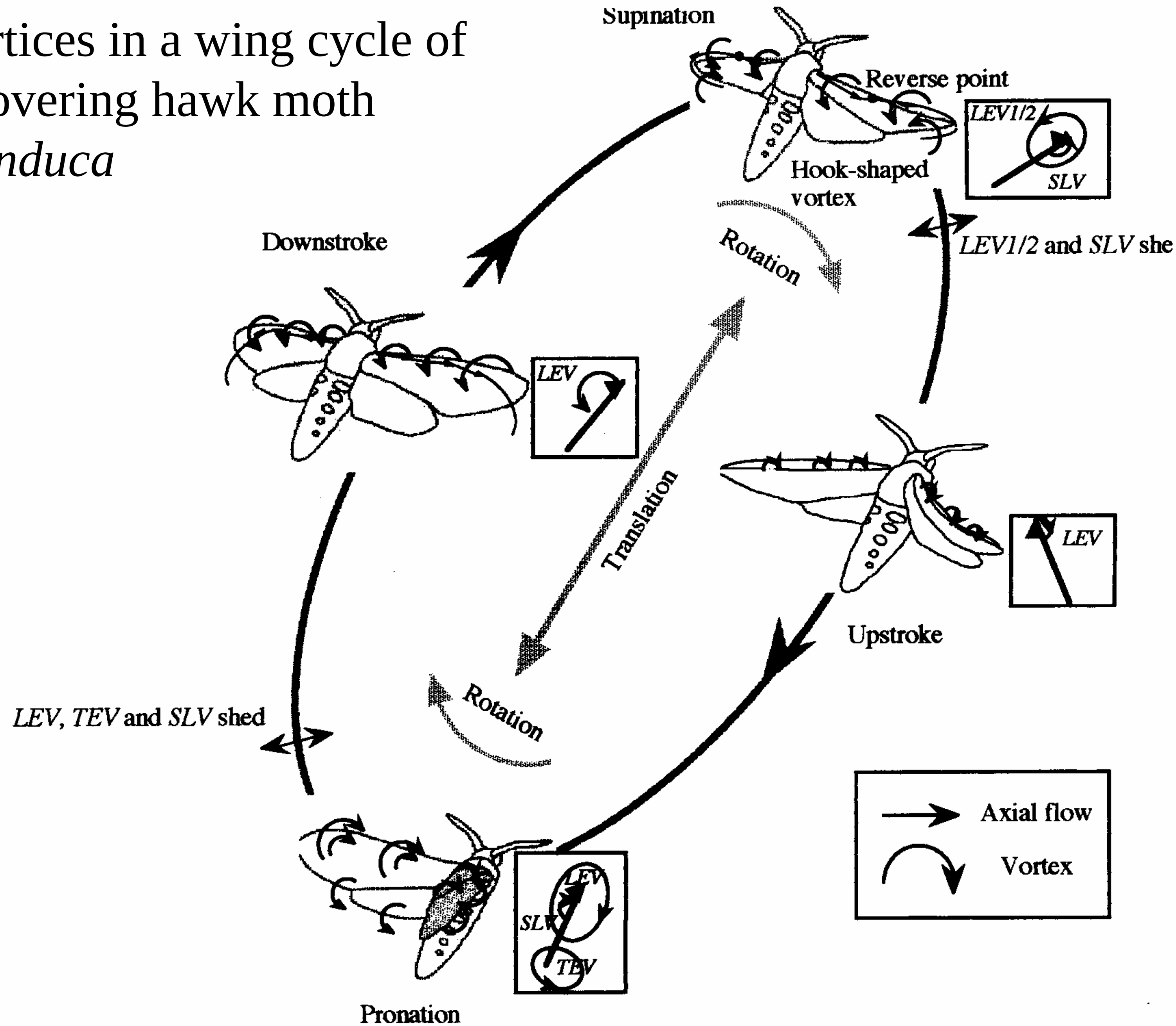






Framework for a lightweight wing
(What's wrong with it?!)

Vortices in a wing cycle of a hovering hawk moth *Manduca*



The power problem

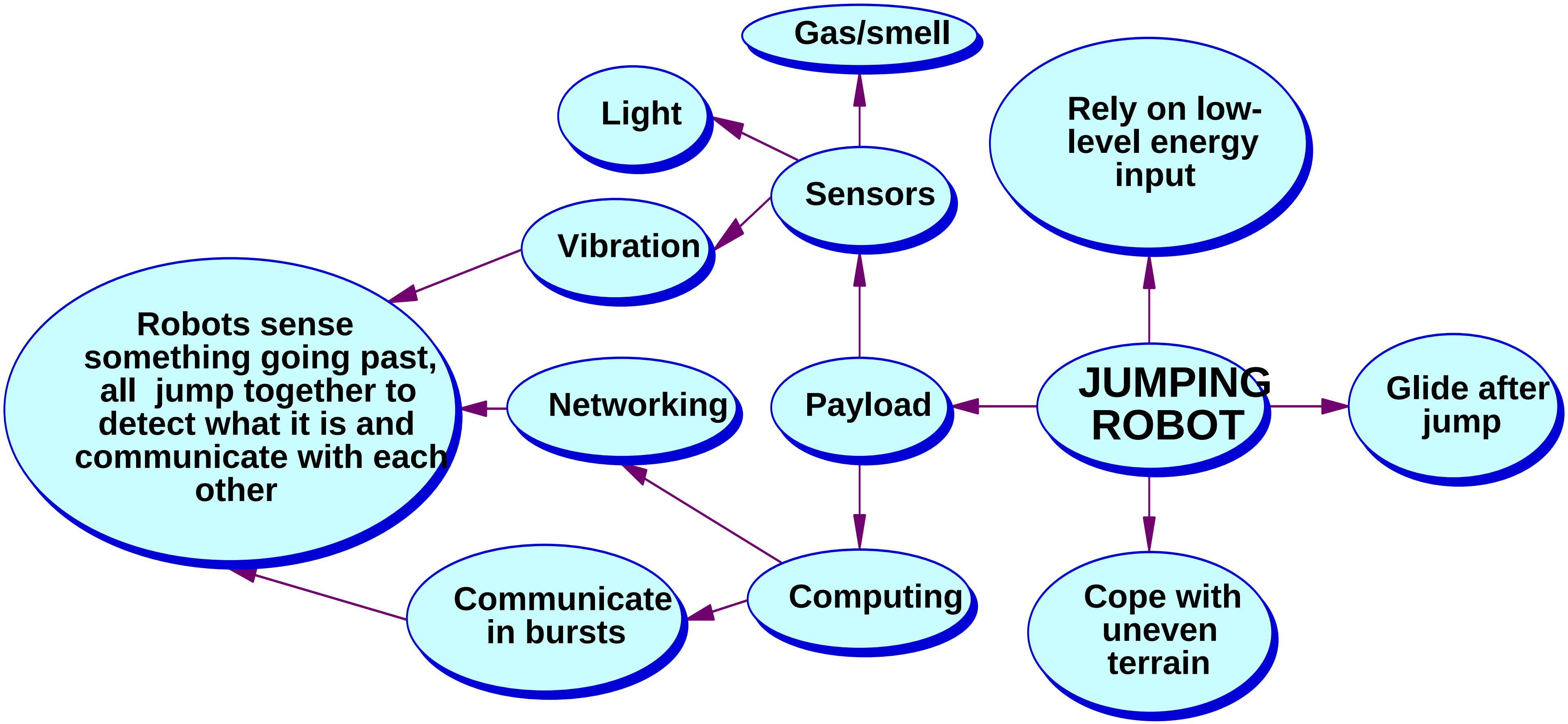
Continual flight needs continual power

Intermittent flight could use low grade energy and store it . . .

. . . then release it suddenly.

power amplification

Jump-and-glide


Gas/smell
Light
Rely on low-level energy input
Sensors
Vibration
Robots sense something going past, all jump together to detect what it is and communicate with each other
Networking
Payload
JUMPING ROBOT
Glide after jump
Communicate in bursts
Computing
Cope with uneven terrain

Height of a jump

Kinetic energy on leaving the ground: $$E_k = \tfrac{1}{2}mv^2$$

Potential energy at the top of the jump: $$E_p = mgh$$

$$\therefore mgh = \tfrac{1}{2}mv^2$$

Height of the jump: $$h = \frac{v^2}{2g}$$

The height of the jump depends linearly on the power available

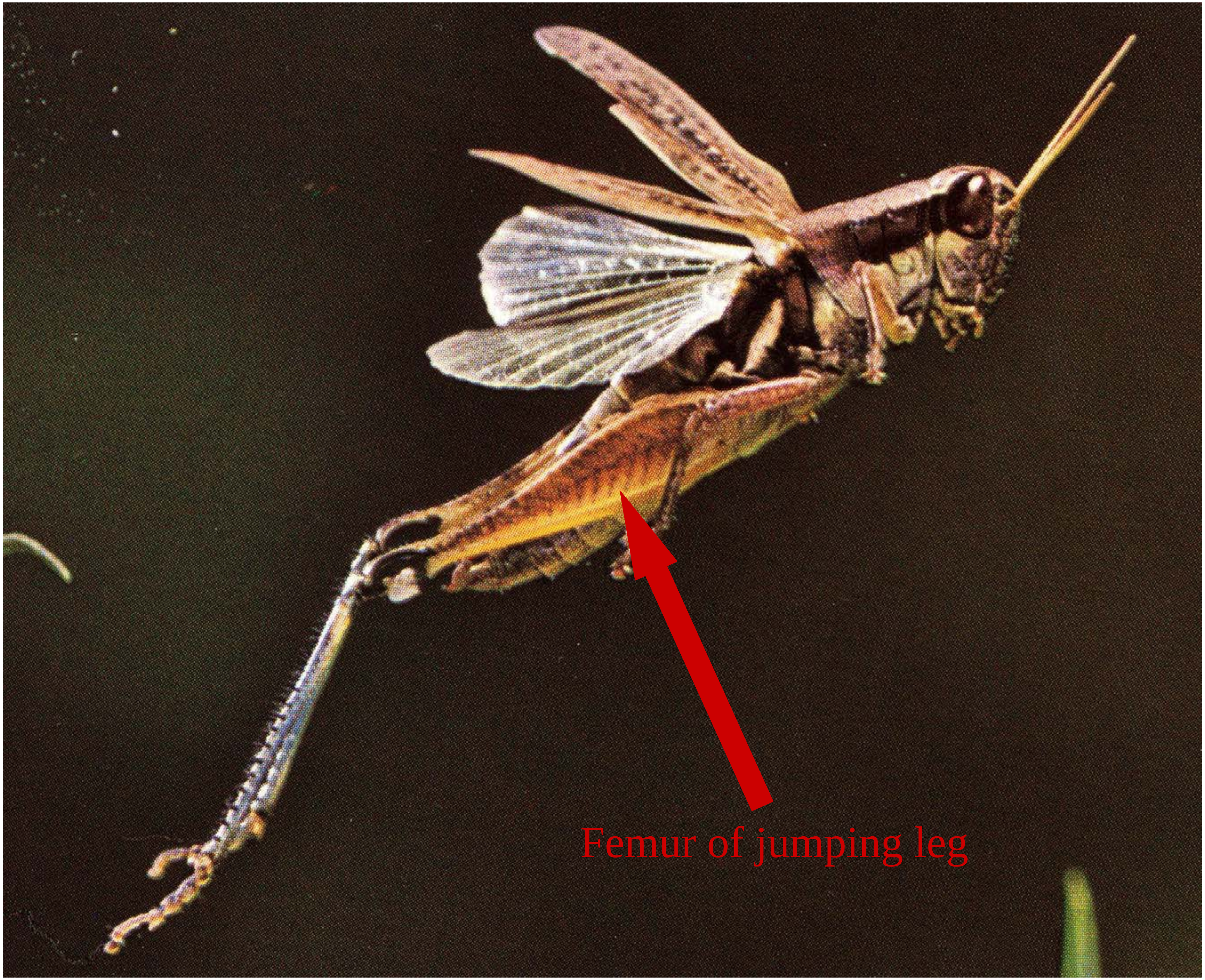
100 g JumpBot

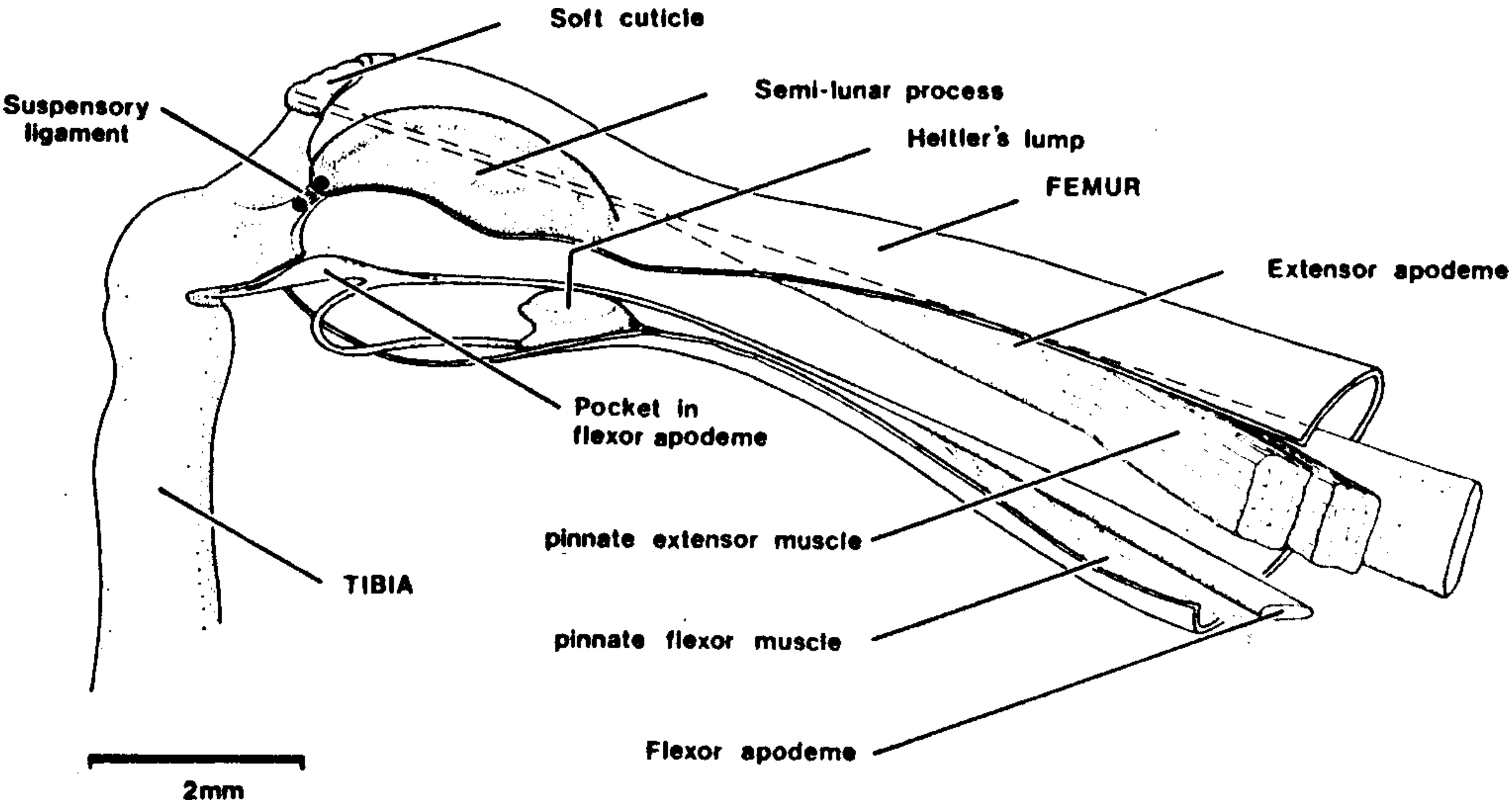
jumps to 1 metre

(assumes 10% spring efficiency)

Computer	> > > > >	30 g
Spring	> > > > >	5 g
Energy in	> > > > >	40 g
Chassis	> > > > >	25 g

n.b. - the chassis will store some of the strain energy

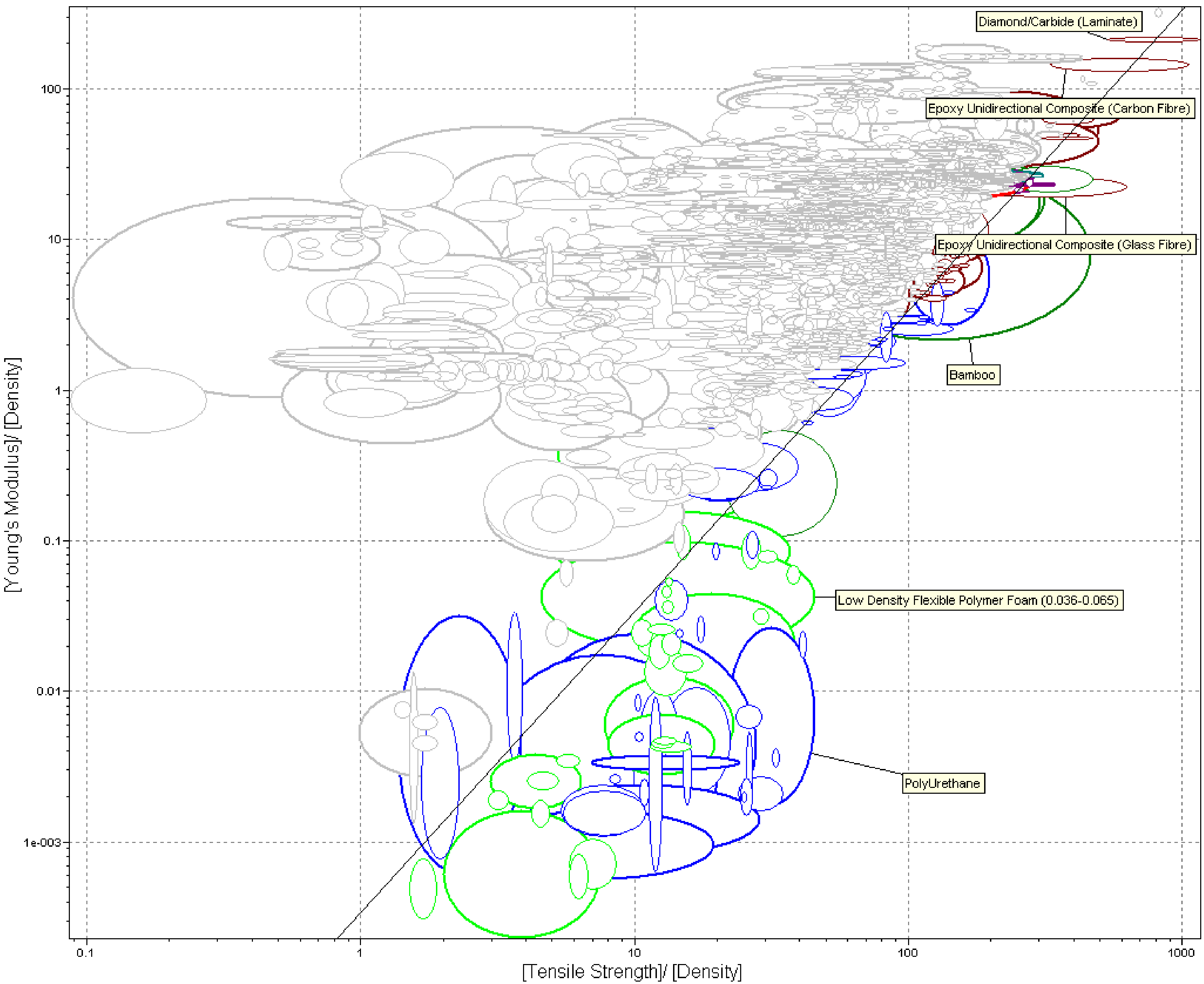

Femur of jumping leg



Bennet-Clarke HC (1975). *J. Exp. Biol.* **63**, 53-83

Mechanical properties of skeletal materials

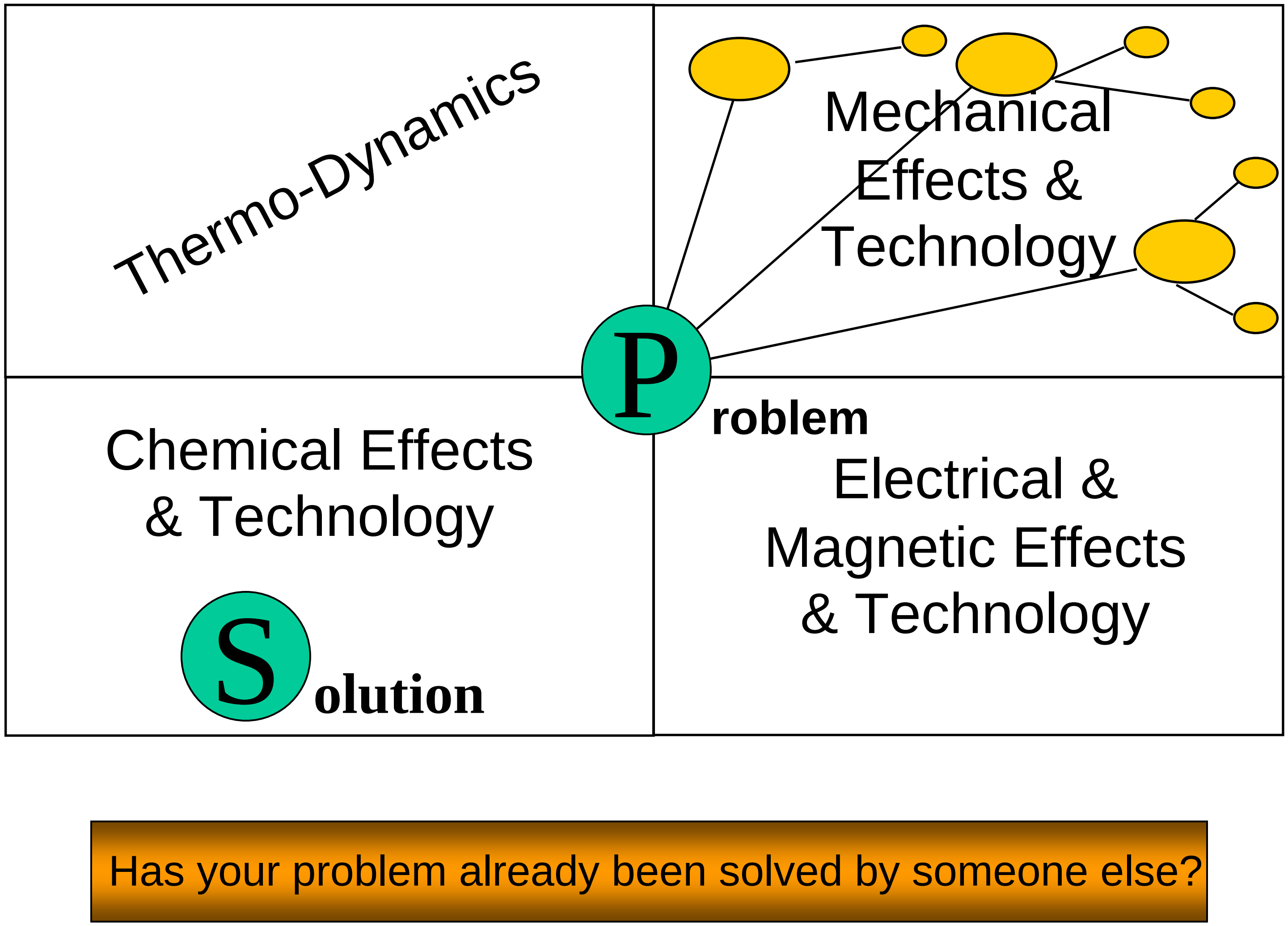
	Locust tendon	Mammalian tendon	Resilin	Steel
Strength (MN/m^2)	600	100	3	450 - 2700
Stiffness (MN/m^2)	20000	2000	2	210000
Elastic strain (%)	3	> 10	> 140	0.45 – 1.3
Energy storage (J/g)	9	> 5	> 2.1	0.125 – 1.4

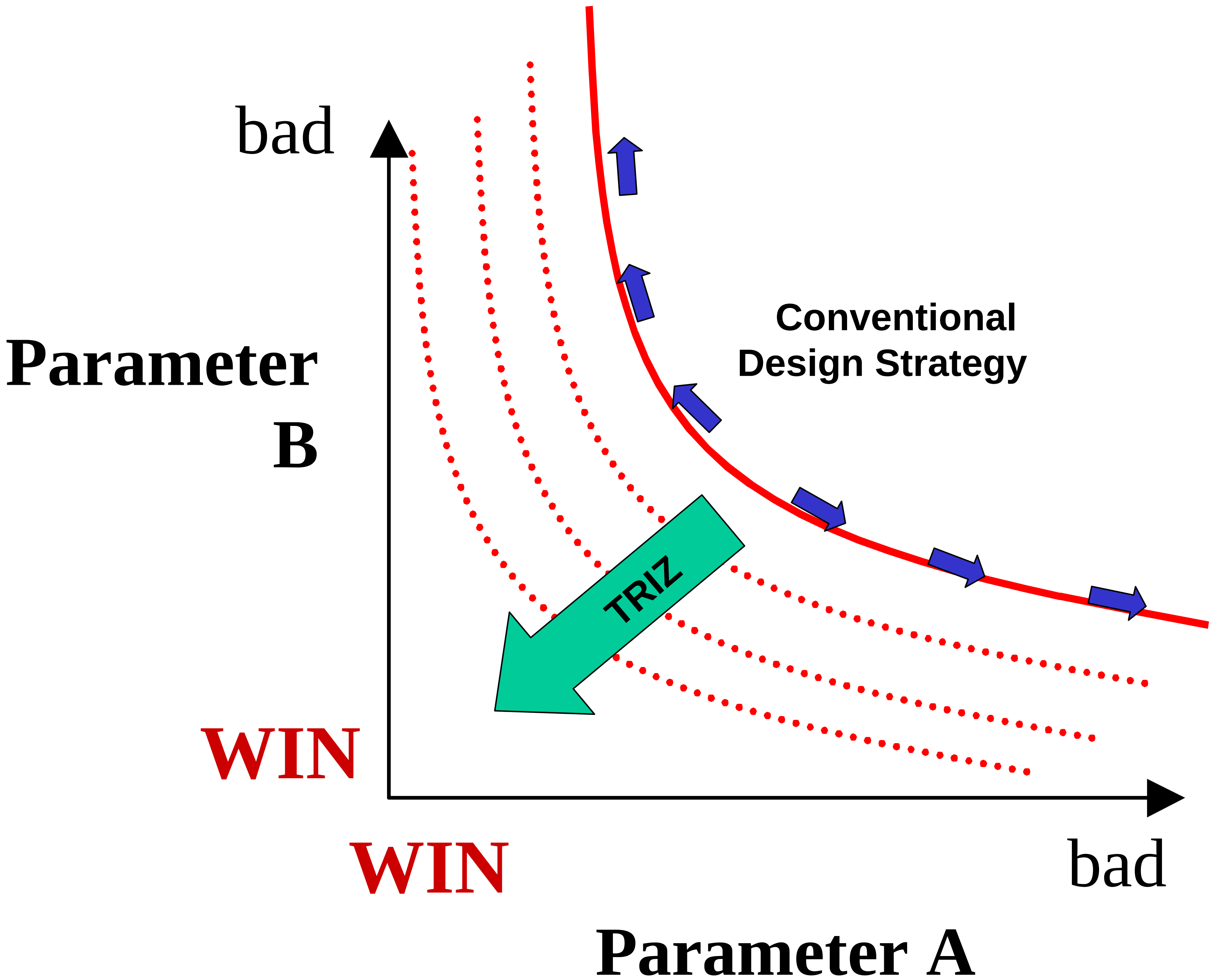

Diamond/Carbide (Laminate)
Epoxy Unidirectional Composite (Carbon Fibre)
Epoxy Unidirectional Composite (Glass Fibre)
Bamboo
Low Density Flexible Polymer Foam (0.036-0.065)
PolyUrethane
[Young's Modulus]/ [Density]
[Tensile Strength]/ [Density]
100
10
1
0.1
0.01
1e-003
0.1
1
10
100
1000

TRIZ

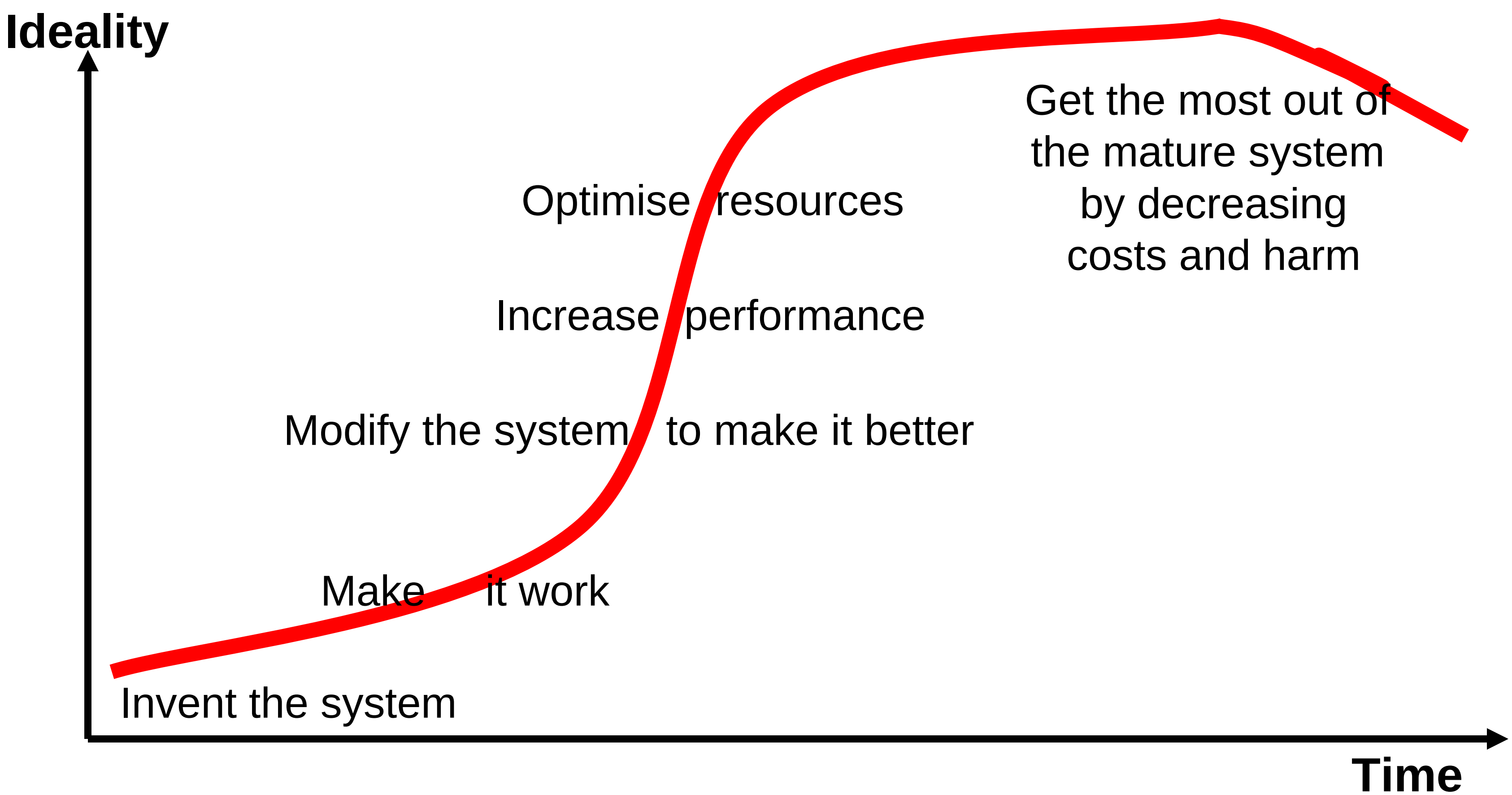
Teoriya Resheniya Izobreatatelskikh Zadatch

Теория Решения Изобретательских Задач

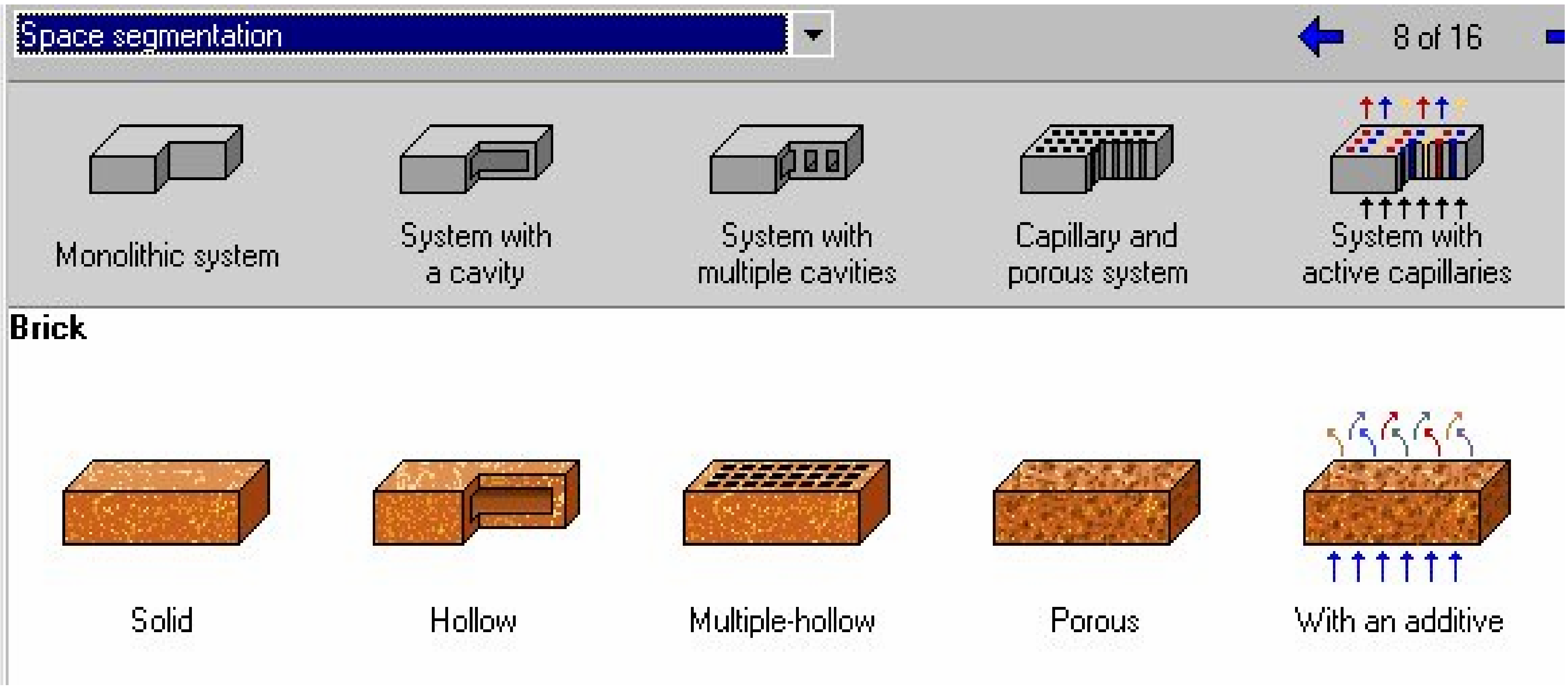

Thermo-Dynamics
Mechanical Effects & Technology
P
roblem
Chemical Effects & Technology
Electrical & Magnetic Effects & Technology
S
olution
Has your problem already been solved by someone else?


bad
Parameter B
Conventional Design Strategy
TRIZ
WIN
WIN
bad
Parameter A

Increasing Ideality



Space segmentation

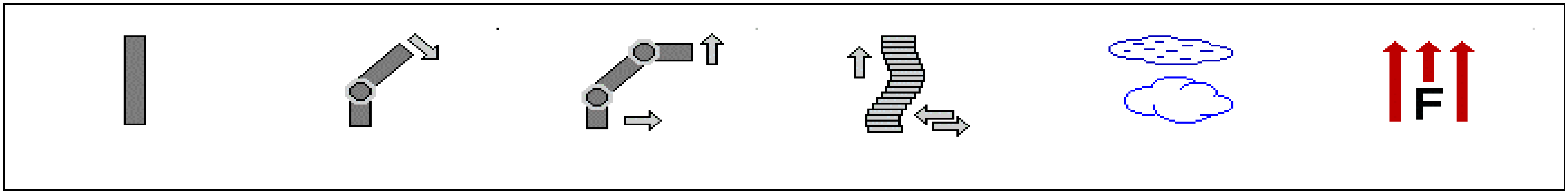


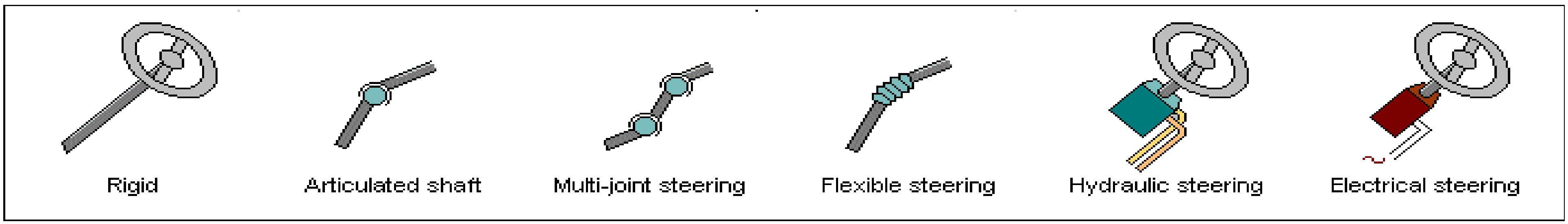
With permission from Invention Machine- Trends example from TechOptimizer Software

Dynamisation

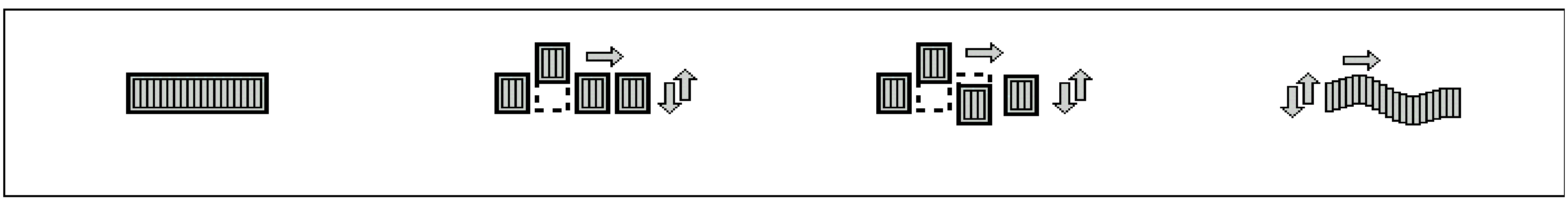
increasing degrees of freedom

Immobile System | **Joint** | **Many Joints** | **Completely flexible** | **Fluid** | **Field**





Rigid System | Partially Mobile Objects | Maximum Mobility of Objects | Multiple Mobile Objects



Principal TRIZ Tools

TRIZ offers a comprehensive series of creativity and innovation tools, methods and strategies. The main tools include:-

* **Contradictions**/40 Inventive Principles
* **Ideal Final Result**
* **Trends of Evolution**
* **Function/Process Analysis**
* **Use of Resources**
* **Scientific Effects/Knowledge**
* **S-Field Analysis**/76 Standard Inventive Solutions
* **Feature Transfer**
* **Subversion Analysis**
* **STC/SLP/System Operators**
* **ARIZ** (Algorithm for Inventive Problem Solving)

The tools shown in red can use information from nature. Hence TRIZ can drive biomimetics by organising and targeting information. Biomimetics can drive TRIZ with new “patents”.

Lessons

- It’s possible to learn from nature
- Huge changes in context are possible
- Most of nature’s design can be (carefully!) dumped
- Biologists are essential to differentiate functions
- A virtuous circle exists between bio- and tech-
- Bio-solutions have control built in to the material and the design

Successful biomimetics

Biologist required who must be able to . . .

. . . identify essential functions

. . . recognise evolutionary baggage

. . . recognise developmental baggage

. . . recognise metabolic baggage

. . . talk to non-biologists

Recommendations

- True interdisciplinary team needed
- The biologist must be there at all times
- Expect unexpected solutions
- Recognise that many solutions are not used by nature . . .
- . . . and that natural solutions may be used non-optimally
- Frame problems as **FUNCTIONS**